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Features

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Lab moves close to 'problem-solving' spacecraft

by John Browlee, Space Vehicles Directorate

KIRTLAND AFB, N.M. — Launched recently aboard the Space Shuttle Atlantis is the first scientific payload bound for the new International Space Station (ISS). If Air Force hopes are realized, the experiment may mark the road to a whole new generation of "smart" spacecraft able to make decisions and solve problems — all without human intervention.

Managed by the Air Force Research Laboratory and slated to begin in October on the ISS, this experiment, dubbed MACE II (Middeck Active Control Experiment Reflight) is a significant move toward spacecraft autonomy. It consists of a hardware/software package that will independently learn to control motion-dampening technologies and suppress unwanted vibrations.

TECHNOLOGY CORRECTS 'ON THE FLY' — Pictured is the original MACE experiment aboard the Endeavor in 1995. The MACE II experiment consists of a hardware and software package that will independently learn to control motion-dampening technologies and suppress unwanted vibrations.

"If MACE II software can control our deliberately induced vibrations (which are typical to spacecraft subsystems), it will be an important contribution in the eventual design of self-reliant spacecraft able to 'think through" and solve many of their own problems," said Rory Ninneman of AFRL's Space Vehicles Directorate. "Building spacecraft that are more autonomous and reducing the human factor now required for spacecraft management will inherently result in lower costs and permit more flexible and reliable missions."

Performed by the ISS crew, the experiment will be the first demonstration of "autonomous adaptive structure control" in space Ninneman said. The essence of MACE II is that it creates the necessary control instructions "on the fly" to counteract unwanted disturbances without any input from a human being. These vibration control algorithms use embedded sensors and actuators to identify and counteract movement, all without requiring extensive modeling or ground testing. The algorithms can also adapt to changes in a structure caused by temperature fluctuations, moving parts, or the normal degradation of mechanical subsystems. Such autonomy is precisely the requirement aerospace engineers have in mind for spacecraft of the future.

"For example, today, if we want to send a spacecraft to orbit the moon, we give it very specific instructions: 'Go to a given point in your trajectory, turn left so many degrees for so many kilometers,'" Ninneman said. "But in the future, spacecraft will have more complexly detailed objectives, such as traveling to the far side of the moon for photographs. Our efforts now will eventually enable these higher-level missions, and as a result, the spacecraft itself will determine how to accomplish them."

An example of how MACE II-like technology might help avert a spectacular disaster is in an aircraft where an engine explosion causes the aircraft to lose hydraulic control of its flaps, rudders, and ailerons.

Perhaps if adaptive control technology is available to the pilot, he might push a 'panic button' that engages a problem-solving autopilot, said Ninneman. It might lower only the landing gear on one side of the aircraft for drag, and increased engine thrust on the other, giving the aircraft at least some ability to maneuver out of harm's way.

Managed by AFRL's Space Vehicles Directorate, MACE II is supported by two science teams. AFRL's team includes Planning Systems, Inc., Melbourne Controls Group, of Melbourne, Fla.; Payload Systems, Inc., of Cambridge, Mass.; the University of Michigan; Virginia Tech; and Sheet Dynamics, Ltd., of Cincinnati, Ohio.

The other team, managed by the Massachusetts Institute of Technology (MIT), includes Lockheed Martin; Midé Technology Corporation of Cambridge, Mass.; and NASA's

Langley Research Center. The Air Force Space and Missile Systems Center Space Test Program provides launch liaison with NASA for MACE II.

The MIT-designed MACE hardware first flew in March 1995 aboard the Space Shuttle Endeavour. In that experiment, researchers studied classical vibration control approaches and their applicability to a variety of space-based structures.

MACE II is a cost-effective science program calculated to benefit future Air Force spacecraft as well as the many relevant spin-offs likely for use by industry. **@**